THE CHAROPHYTES OF GREENLAND

Anders LANGANGEN [1] Jørgen B. HANSEN [2] and Henry MANN [3]

[1] Hallagerbakken 82 b, 1256 Oslo, Norway
[2] Botanical Museum, University of Copenhagen, 1123 Copenhagen, Denmark
[3] Biol. Dept., Sir Wilfred College, Mem. Univ. of Newfoundland, Corner Brook, Canada A2H 6P9

ABSTRACT — Based on herbarium studies, eight charophytes are reported from Greenland: *Nitella flexilis, N. opaca, Tolypella canadensis, T. nidifica* f. *groenlandica* nov. form., *Chara canescens, C. contraria, C. globularis, C. globularis* f. *bulbillifera* nov. form. and *C. delicatula*. In addition *Chara baltica* has been reported in the literature. The total number of known species is therefore nine. Of these 9 species five are common in Europe and North America; one (*C. canescens*) has its main distribution in Europe with a few finds in Northeast America; another (*T. canadensis*) has a northern amphi-atlantic distribution; a third (*C. baltica*) has its main distribution in Europe and is found in a few localities in South America. One species (*T. nidifica*) has a European distribution only. The early immigration of charophytes to Greenland and the development of early bird migration routes in this direction lead us to believe that the charophyte flora of Greenland has more affinity to Europe than to North America. Some ecological factors are discussed below for each of the species.

RÉSUMÉ — L'étude de divers herbiers montre que huit espèces de Charophytes sont connues au Groënland: *Nitella flexilis, N. opaca, Tolypella canadensis, T. nidifica* f. *groenlandica* f. nov., *Chara canescens, C. contraria, C. globularis, C. globularis* f. *bulbillifera* f. nov. et *C. delicatula*. De plus, *Chara baltica* y est déja mentionné dans la littérature. Au total, le nombre d'espèces est donc de neuf. Parmi celles-ci, cinq sont communes à la fois en Europe et en Amérique du Nord, l'une d'elles (*Chara canescens*) possédant sa distribution principale en Europe, avec en outre, quelques stations au Nord-Est de l'Amérique. Une autre (*T. canadensis*), possède une distribution nord-amphi-atlantique, une troisième (*C. baltica*) est principalement répartie en Europe avec quelques localités en Amérique du Sud. Enfin, une espèce (*T. nidifica*) n'est connue qu'en Europe seulement. L'immigration primitive des Charophytes vers le Groënland, associée au développement des voies de migration aviaires vers ce pays, nous conduit à estimer que la flore des Charophytes du Groënland possède une plus grande affinité avec la flore d'Europe qu'avec celle de l'Amérique du Nord. Enfin, divers facteurs écologiques ont été examinés pour chacune des espèces citées.

KEY WORDS: Charophytes, Characeae, *Chara, Nitella, Tolypella*, Greenland, ecology.

INTRODUCTION

Greenland is the largest island in the world, situated in the Northern Atlantic, extending from c. 60° N to c. 83° N. The climate is characterised by relatively low temperatures, with the July isotherms between 5-10°C in South Greenland. In spite of this surface temperatures of waters have been measured up to c. 20°C in the same area (Røen, 1971; Fredskild, 1992). Most of the island is covered with ice, but in the ice-free parts of coastal areas there are plenty of ponds and lakes of different sizes and depths. All these waters are ice-covered in winter, and therefore the ice-free period in the summer will determine the vegetative season and be a factor of biological importance for the life in the lakes. The ice-free period is 6 months in South Greenland and in West Greenland, 4 months in Godthb (64° N), and 2½ months in Umanak (70,5° N) (Røen, 1971). Another important ecological factor is the ice-thickness. In many ponds the ice is relatively thick and the vegetation in shallow water is often damaged by the movements of the ice. This is a general problem for the limnophytes. Several salt lakes can be found on the west coast of Greenland. Such lakes are interesting as many species of charophytes prefer brackish water. At the head of Søndre Strømfjord one can find several such lakes, with variable salt contents. A short outline of the known phycology of Greenland is given by Hansen (1985). This article is based on material collected in Greenland mostly during the last 30 years. The collections done by Dr Bent Fredskild, Botanical Museum, Copenhagen have been especially valuable. Material of the charophytes studied here is deposited in the National Museum of Natural Sciences, Ottawa (CAN), Botanical Museum, University of Copenhagen (C) and in Botanical Museum, University of Oslo (O).

OBSERVATIONS

Our knowledge on the charophyte-flora of Greenland is still incomplete, and only based on herbarium studies and information in different botanical articles. These are: Braun & Nordstedt (1882), Hartz (1898), Kruuse (1912), Porsild (1935), Fredskild (1973, 1992). So far, no charophytes have been found in the hot springs of Greenland (Halliday *et al.*, 1974), contrary to Iceland and Svalbard (Langangen, 1972, 1979). The localities are given as stated on the herbarium labels, and all ecological information found on these labels have been extracted.

The species of charophytes found in Greenland are listed below.

Species found in different herbaria

***Nitella flexilis* (L.) C. Agardh**
Three localities in Greenland (Fig. 1).

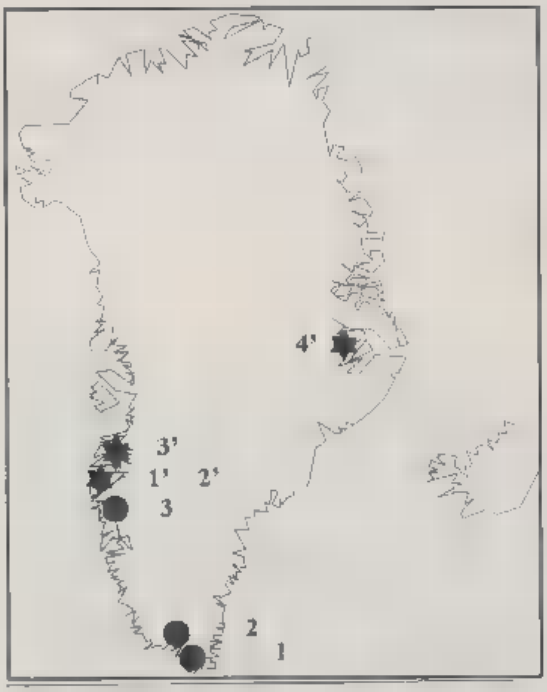

Figure 1. ● Known distribution of *Nitella flexilis* in Greenland. ★ *N. opaca vel flexilis*.

1. South Greenland: Kugssuaq: 13 July 1964. Lat. 60°16′ N, Long. 44°43′ W. *Leg.* Carlo Hansen, Peter Milan Petersen, Tem Smitinand (C). Specimens up to 7 cm high. Richly fertile, antheridia 500 µm, oogonia 600 µm. No ripe oospores. With sterile *Coleochaete scutata* Bréb. on internodia.

2. South Greenland: Igaliko, 3 August 1937. Lat. c. 61°00′ N, Long. c. 45°30′ W. *Leg.* Johs. Gröntved (C). Specimens up to 9 cm long. Relatively rich fertile, mostly with oogonia, only few antheridia. A few brown oospores were found.

3. West Greenland: Søndre Isortoq. 1977. Lat. 65°30′ N, Long. 52°10′ W. *Leg.* Sune Holt (C). Specimens up to 10 cm long. 2-3 whorls, with internodes 3-4 cm. One fertile head with mostly unripe oogonia. Only one antheridium was found, 500 µm in diameter.

Comments: The species has also been reported from West Greenland: Godthåbsfjord, Lake at Itivnera (Fredskild, 1973), but this find is not confirmed by any herbarium specimens. *Nitella flexilis* is undoubtedly more common. *Nitella flexilis* is a widespread species, common in Europe, and also found in parts of North America (Corillion, 1957), including insular Newfoundland (Mann, 1989). The species is also known from Iceland (Langangen, 1972).

The map in Wood (1967) shows that the northernmost localities of *Nitella flexilis* are situated in Newfoundland, but this *Nitella flexilis* is based on another species concept (Wood, 1965) which include many so called microspecies (e.g. *N. opaca*, see later). *Nitella flexilis* is known to have a broad ecological amplitude and is therefore well-known from "cold" areas. Kashimura (1960) showed under experimental conditions that the species developed best at low temperatures, with the best growth of the gametangia at 5-10°C. This was also confirmed by observations in different lakes, where gametangia were never found in summertime.

In some lakes, probably with unfavourable conditions (temperature) one can find only sterile specimens which must be named *Nitella flexilis vel opaca*. This because the two species can only be separated in fertile status, since *Nitella opaca* is dioecious and *N. flexilis* is monoecious (Olsen, 1944; Moore, 1986). In the Copenhagen herbarium there are four collections of sterile *Nitella opaca vel flexilis*. The four localities are:

1′. West Greenland: Holsteinsborg, Vandsøen ("The Water Lake"): 21 August 1975. Lat. 66°56′ N, Long. 53°40′ W. *Leg.* Bent Fredskild (C). The lake is described in Røen (1962). Specimens up to 10 cm high.
2′. West Greenland: Holsteinsborg, Akugdleg, "Boresøen": 29 July 1978. Lat. 66°55′ N, Long. 52°18′ W. *Leg.* Bent Fredskild & Peter Friis Møller (C). Altitude of the lake is 85 m., depth of growth 2.5 m. Specimens up to 20 cm high.
3′. West Greenland: Nordre Isortoq, Arnaq qavdlunâq: 13 September1956. Lat. 67°16′ N, Long. 53°23′ W. *Leg.* Tyge W. Böcher (C). Small, tiny specimens.
4′. East Greenland: Scoresby Sund, Rypefjord, SW-coast. 1958. Lat. 71°02′ N, Long. 27°45′ W. *Leg.* S. Lægaard (C) (Lægaard, 1960). The altitude of the lake is c. 100 m. Coarse specimens.

Nitella opaca C. Agardh
Two localities in Greenland (Fig. 2).

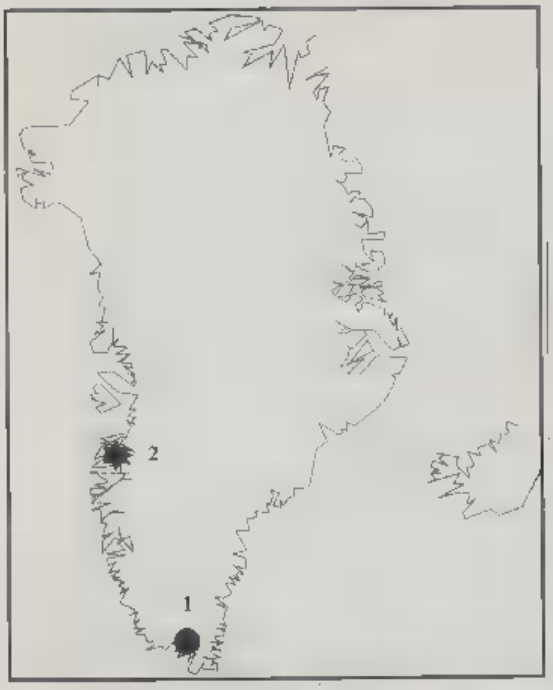

Figure 2. Known distribution of *Nitella opaca* in Greenland. ★ loc. given in literature.

1. South Greenland: Igaliko, 31 July 1937. (Lat. c. 61°00′ N, Long. c. 45°30′ W). *Leg.* Eilif Dahl (O). Coarse, well developed specimens, broken. Oogonia well developed in many specimens, but most of them are white and immature. One black oospore was found.
2. West Greenland: Nordre Strømfjord, Sofies Havn (Lat. 68°21′ N, Long. 51°06′ W). *Leg.* A. Berlin (C) (Böcher, 1954: 299). We have not seen specimens.
Comments: *Nitella opaca* has also been found in several lakes in Iceland (Langangen, 1972) and is quite common in insular Newfoundland (Mann, 1989). The species is also common in the British Isles (Moore, 1979). *Nitella opaca* has an ecology similar to *Nitella flexilis, Chara globularis* Thuill. and *C. delicatula* C. Ag.

Tolypella canadensis Sawa
2 localities in Greenland (Fig. 3).

This species has been referred to as *Nitella translucens* (Pers.) C. Agardh in different articles on Greenland botany. The herbarium specimens examined were all in relatively bad condition.

Figure 3. Known world distribution of *Tolypella canadensis*. See Sawa (1973) for North American localities and Langangen & Blindow (1995) for Scandinavian ones.

1. West Greenland: Umanak, Innfjorden in fresh water. 11 September 1932. Lat. c. 70°30′ N Long.c. 51°20′ W. *Leg*. J. Devold. (O). Specimens more or less broken into small pieces. Whorls with 4-5, single branchlets, 1-2 cm long, 3-4 celled including mucro. The mucro consists of one or two short cells. All specimens are sterile.
2. West Greenland: Christianshb. 18 July 1890. Lat. c. 68°50′ N Long. c. 51°10′ W. *Leg*. N. Hartz (C) (Hartz, 1898; Porsild, 1935; Böcher, 1954). Old, fragile specimens, partly broken. Some plants up to 20 cm high, with up to 7 whorls, with 4-5 once-forked (single) branchlets and internodes to 2-3 cm long. Some branchlets with mucronate 1-2 celled dactyls (end-cells). Other with longer cells, and short, one mucronate end-cell (Fig. 4). All specimens are sterile.

The species has also been reported from Kap Hørring (sea in the western part of Amaka in East Greenland) by Kruuse (1912). We have not seen any specimens, and as the determination is doubtful, this locality is not marked in figure 3.

Comments: Specimens studied here are all in bad condition, but they have all the taxonomic details typical for sterile members of the genus *Tolypella*: branchlets of simple type, being progressively shorter and thinner toward the apex; monopodial arrangement of the branchlets; two or more branches from the whorls (Groves & Bullock-Webster, 1920; Allen, 1950). When Hasslow (1939) described this taxon for the first time he named it *Nitella mucronata* (A. Braun) Miquel f. *haplophylla* Hasslow, which refers to the superficial similarity with this species. It has later been described as a new species to science by Sawa, based on material from Canada (Sawa, 1973).

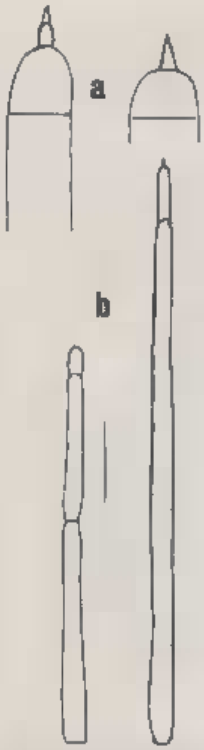

Figure 4. *Tolypella canadensis* collected in Christianshåb, Greenland, in 1890. a. End of branchlets with mucronate end-cells. Scale 350 µm (left) 200 µm (right). b. Two branchlets of divergent form. Scale 2 mm.

In Greenland and in Scandinavia the species has been found in oligotrophic waters. In the two Scandinavian localities it is mostly found in lakes with some turbulent water. It seems to prefer fine sandbottom, waters poor in electrolytes and pH around 7.0. The waters are also relatively "cold", which is also the case in Greenland. Both Canadian and Scandinavian specimens are fertile, in contrast to specimens from Greenland, which are all sterile. This can perhaps be explained by lower temperatures and shorter vegetation period in Greenland. The specimens from Greenland fits with f. *glomdalensis* (Langangen, 1993a).

Tolypella nidifica Leonh. f. *groenlandica* nov. form.
Only one locality in Greenland (Fig. 5).

Figure 5. Known distribution of *Tolypella nidifica* in the northern Hemisphere. For localities out of Greenland, see Corillion (1957) and Moore & Greene (1983).

1. West Greenland: Søndre Strømfjord, Brayasø: 27 August 1977. Lat. 66°59′ N, Long. 51°02′ W. *Leg.* Bent Fredskild (C). Two small specimens, with the mother-oospores still attached, not encrusted. One of the specimens has six plants from its protonema, and one of these has a 6 cm long unbranched terminal process, 1 mm broad. Protonemal internode up to 2 cm long. 5 or 6 fertile heads, each with 3-4 whorls. Internodes to 2 cm, and stem-diameter up to 750 µm. All whorls fertile, with 6 (more?) short 2-3 celled branchlets, to 1.5 cm long with 2-3 celled laterals. Penultimate cells of branchlets usually 2x the length of the ultimate cells. End-cells obtuse. Richly fertile, mostly oogonia. Oogonia 1-3 at a node, 500-600 µm long (excl. coronula), 400-450 µm broad, spiral cells with 8 convolutions, in many cases with swollen apex, and with coronula fallen off. Oospores in abundance, 350-375 µm long, 275-300 µm broad, brown to dark brown. Membrane with linear granulation parallel to the ridges. Fossae 50-55 µm. Antheridia 275 (immature) to 450 µm in diameter.

The specimens described here, differ from the type mentioned above in many respects. Therefore we want to describe it as a new form.

***T. nidifica* Leonh. f. *groenlandica* nov. form.**

Plantae parvae. Tolypella nidifica-*similis. Non incrustatae, viridianae. Protonematis filamentum terminalis major, ad 6 cm longis, ad 1 mm brevis. Fertilia capitula formans, 3-4 verticilla. Internodia ad 2 cm, ad 750 µm diametro. Omnia verticillia fertilia, ramuli 6, 2-3 cellulares, laterales 2-3 cellulares. Cellula ultima conica et obtusa. Oogonia 1-3 ad nodum, 500-600 µm longa (coronulis exclusis), 400-450 µm lata, cellulae striae 8. Oosporae brunnae, 350-375 µm longae, 275-300 µm latae. Fossae 500-550 µm. Antheridia ad 450 µm diametro. In lacu Brayasø in Søndre Strømfjord, Kalaallit Nunaat collegit Bent Fredskild.*

The locality is described in Røen (1962), who says "Along the banks there are growths of *Potamogeton filiformis* Pers. and a great many filamentous algae." He gives the following chemical parameters, which indicate brackish water: specific conductivity 3000 µS cm^{-1}, pH 8.5, alkalinity 178 mg l^{-1}, calcium 13.0 mg l^{-1}, magnesium 182.2 mg l^{-1}, chloride 1240.0 mg l^{-1}. It would be of great interest to survey this locality closer for charophytes.

Tolypella nidifica is a brackish water species, and the find in Greenland is very interesting. *Tolypella nidifica* is a species only found in Europe and northern Africa (Corillion, 1957). In Greenland there are many potential salt lakes where this species can be found, especially in inland fjord heads. In Newfoundland, Mann (1994) has found *Tolypella glomerata* Leonh. which is a similar species. Oospores of *Tolypella* have recently been found by Eisner *et al.* (1995) in the same area, in lake 31, near to Mt. Kegelen and dated to 4,000-3,000 B.P. After this time *Tolypella* disappeared from this lake, but has survived in other lakes. This indicates a much wider distribution of the species in this period. *Tolypella* seems able to adapt very well to extreme localities (low temperature, high salt content, etc.), by rapid development e.g. by producing fruiting structures very fast (Mann, 1994), by producing ripe oospores after three months of growth (Moore, 1986), and keeping the protonemal terminal process as the main photosynthetic organ as do the specimens studied from Greenland. This is a survival strategy which is known from several species, like *Tolypella normaniana* Nordstedt in Norway (Langangen, 1994), *T. antarctica* (A. Braun) R. Corillion in Kerguelen Island (Corillion, 1982; Corillion & Reviers, 1985) and *T. salina* R. Corillion in France and Spain (Corillion, 1960; Comelles, 1986). Among the Greenland limnophytes there is only one endemic taxon, *Potamogeton pusillus* (Müll.) Leonh.

subsp. *groenlandicus* (Fredskild, 1992). The speciation of this taxon must have taken place during Holocene, as it could not survive any glaciation. A similar development can be applied on *Tolypella nidifica* f. *groenlandica*. Further investigations are necessary for deciding whether this taxon should have subspecies or species rank. As the Greenland specimens were fertile with ripe oospores, this indicates a well adapted taxon as well as favourable conditions in the lake.

***Chara canescens* Desv. & Lois.**
Only one locality in Greenland (Fig. 6).

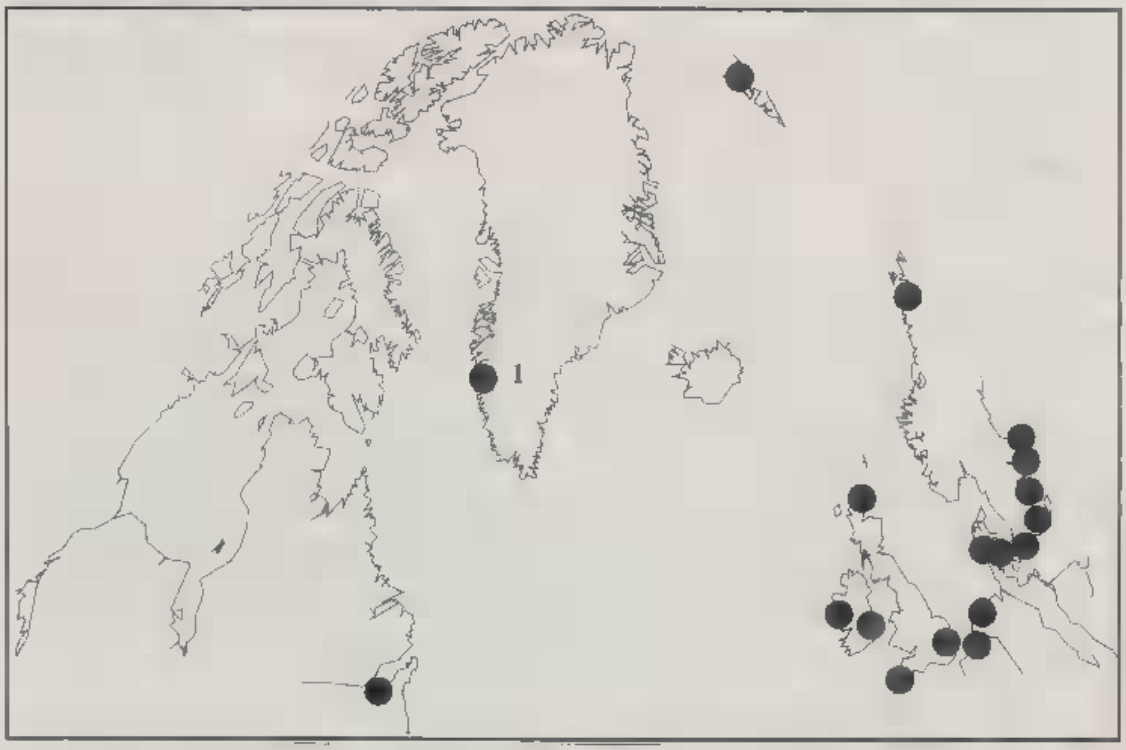

Figure 6. Known distribution of *Chara canescens* in N.W. Europe and N. America. For localities out of Greenland, see Robinson (1906), Corillion (1973) and Langangen (1972).

1. The location of this collection is doubtful. On the label (C) is written: "Chara spec. inter Conferv. Wormskioldii e Grönlandia". This means: a *Chara* mingled with *Conferva wormskioldii* Mertens *ex* Horneman (now *Urospora wormskioldii* (Mertens) Rosenvinge) from Greenland. Collector, locality and date are not given on the label. Only one single specimen. 36 mm high. Diameter of stem 400 µm. 5 internodes, 1 mm (top), 2.8 mm, 3.8 mm, 4 mm and 5 mm (lowest). Cortex normal haplostichous, with spine-cells on all rows. Spine-cells 200-350 µm long. Stipulodes developed in two rows, cells to 250 µm long. In each whorl 5-7 branchlets, length up to 5 mm and 1.2 x as long as internode. Number of segments on each branchlet 3-4. End-segment with 2-3 cells up to 1 mm long. End-cell short acute. Bract-cells and bracteoles of equal length, 300-500 µm, slightly shorter than oogonia. Only female plants. Relative rich fertile, but no mature oogonia (only white), 450 µm long.
Comments: *Conferva wormskioldii* was described as a new species in Horneman (1816). The description was made on specimens collected by Wormskiold around Godthb in

1812 (Burrows, 1991). Wormskiold travelled along the westcoast from the isle of Disko at 69° N to Julianehåb at 61° N in the years 1812-1813 (Warming, 1890; Hansen, 1985; Jessen, 1987; T.Christensen, 1991). The condition of the studied specimens indicates that they are collected in the late summer or autumn, and as Wormskiold in autumn 1812 was in the Godthåb area and in the autumn of 1813 in the Fredrikshäb area, the charophyte may have been collected in one of these areas. We know that he sent material to Hornemann in Denmark already in September 1812, which was material from Godthåb (Jessen, 1987). The herbarium label is written by Hornemann in Denmark. *Conferva wormskioldii* is marine, but can be found in brackish water as well (Burrows, 1991). *Chara canescens* is a brackish water species (Stroede, 1933; Olsen, 1944) and can potentially be found in salt lakes on the west coast (e.g. Søndre Strømfjord). *Chara canescens* is found in Europe, in the north-eastern part of North America (Robinson, 1906; Corillion, 1973) and Newfoundland (Mann, 1989). The species is also reported from Svalbard (Langangen, 1972). As the species is richly fertile, it must have grown under good conditions.

***Chara contraria* A.Br. *ex* Kützing**
Only one locality in Greenland (Fig. 7).

Figure 7. Known distribution of *Chara contraria* in N.W. Europe and N.E. America. For localities out of Greenland, see Corillion (1957), Moore (1979) & Mann (1989).

1. West Greenland: Søndre Strømfjord, Lake Jean: 27 August 1977. Lat. 67°00′ N, Long. 50°58′ W. *Leg.* Bent Fredskild (C). Specimens up to 6 cm high. Strongly encrusted. Cortex diplostichous, tylacanthous. Diameter of stem 600 µm. Spine-cells solitary, to 300 µm long. Stipulodes short, in two rows. Branchlets to 8 mm long, varying from 0.5x to 1x length of internodes. Bracteoles and anterior bract-cells about

equal in length to the oogonium. Posterior bract-cells papillate. Very rich fertile with ripe, black oospores on lower, short branchlets. Length of ripe oospores 600 µm. The specimens studied formed small bushes, mingled with mosses. The "Lake Jean" is situated c. 250 m above sea level.

Comments: *Chara contraria* is a cosmopolitan species (Corillion, 1957; Wood & Imahori, 1959). It is frequently dispersed throughout Europe (Corillion, 1957) and common in the British Isles (Moore, 1979). In the relevant parts of North America it is reported from Quebec and insular Newfoundland in Canada (Robinson, 1906; Mann, 1989) (Fig. 7). This species seems to prefer alkaline waters with a high content of calcium (lime-rich), and is therefore generally highly encrusted (Olsen, 1944; Langangen, 1974; Mann, 1989). Specimens with slightly or lack of encrustation are known (Langangen, unpublished data; Mann, 1989). The species is in general reported from fresh water, but records from slightly brackish water are known (Stroede, 1933; Langangen, unpublished data from Northern Norway, 1993b). The heavy encrustation of the specimens from "Lake Jean", suggests a calcium rich lake. This is not common in Greenland. Unfortunately we do not have chemical measures from this locality. Another interesting fact is that the species is very fertile and has been found with ripe oospores. *Chara contraria* is a species well adapted to low temperatures (Corillion, 1957), and it is found in high altitudes (3700 m in South America, Braun & Nordstedt, 1882) and in far north localities in Norway (Langangen, 1974). The find of this species in Greenland is very interesting, as it provides a link between the European and the American areas of distribution.

Chara globularis Thuill. (= *C. fragilis* Desv.)

10 localities in Greenland (Fig. 8). All specimens studied are slightly encrusted.

Figure 8. Known distribution of *Chara globularis* in Greenland.

1. West Greenland: Søndre Strømfjord, lake just W of Mount Keglen. 1 August 1977. Lat. 67°02′ N, Long. 50°33′ W. *Leg.* Bent Fredskild (C). Specimens 20-30 cm high. Some fertile specimens, but no ripe oospores. Bracteoles shorter or as long as the oogonium. Anterior bract-cells shorter than oogonium and posterior bract-cells papillate.

2. West Greenland: Søndre Strømfjord. July 1942. Lat. 66°56′ N, Long. 50°50′ W. *Leg.* A. E. Porsild. (CAN) (Böcher, 1954). Only a small amount of material. Specimens up to 9 cm in length. Lightly encrusted. Sterile. There is a fine pale-brown sandy substrate on the "roots".

3. South Greenland: Tasiussaq, in a pond, 2 September 1985. Lat. 61°09′ N, Long. 45°40′ W. *Leg.* Jon Feilberg (C). Specimens 20 cm high. Branchlets up to 2 cm long, 1-2x length of the internodium. Anterior and posterior bract-cells papillate. Bracteoles as long as the oogonium. Slightly fertile, undeveloped gametangia.

4. South Greenland: Lake west of Qagssiarssuk, 5. July 1970. Lat. 61°09′ N, 45°33′ W. *Leg.* Bent Fredskild (C). Specimens up to 25 cm high. Sterile. In association with *Chara delicatula*. Sterile *Coleochaete scutata* on the stem.
5. South Greenland: Lake 1.5 km west of Qagssiarssuk (Tunugliarfik-fjorden). 29 June 1962. Lat. 61°09′ N, Long. 45°32′ W. *Leg.* Bent Fredskild. Same locality, 31 July 1962. *Leg.* Bent Fredskild (C) (Fredskild, 1992). Specimens, from June 5-6 cm high, from July 10 cm. Well developed bulbils on the lowest nodes. All specimens sterile. *Chara globularis* f. *bulbillifera* (see next paragraph).
6. South Greenland: Lake c. 2 km NW of Igaliko (on the isthmus between Igaliko and Tunugliarfik). 24 July 1962. Lat. 61°01′ N, Long. 45°27′ W. *Leg.* Bent Fredskild (C). Specimens 4-5 cm high, growing in small dense tufts on sandy bottom. End segments of branchlets 2-4 celled, without cortex. 0.1-0.5x length of branchlet. Anterior bract-cells and bracteoles 2-3x longer than oogonium (immature), up to 1.2 mm long. Posterior bract-cells papillate. Some specimens are fertile on the youngest whorls, with immature gametangia. Well developed, composite rootbulbils, attaining a diameter of up to 2 cm. Bulbils are not often found in *Chara globularis*. We want to describe the specimens found here (Nos 4 and 5) as a new form, *Chara globularis* f. *bulbillifera*. This taxon corresponds with *Chara delicatula* var. *annulata* (Liljeb.) J. Groves & G.R. Bullock-Webster, which has similar bulbils. The bulbils are an important vector for vegetative reproduction which is presumed to be of adaptive value in these regions.

Chara globularis Thuill. f. *bulbillifera* nov. form.

Plantae ad 4-5 cm altae. Bulbilla radicum, ad 2 cm diametro.
7. South Greenland: Hestesporsø, 8 August 1988. Lat. 60°53′ N, Long. 45°18′ W. *Leg.* Bent Fredskild (C). Specimens 5-6 cm. Slightly fertile, with small, undeveloped gametangia. Most specimens are sterile. Other species in the lake are *Myriophyllum alterniflorum* DC. and *Potamogeton gramineus* L. Altitude c. 110 m above sea level. pH = 7.7 and specific conductivity 112 µS cm^{-1}.
8. South Greenland: Lake east of Søndre Igaliko, 3 August 1988. Lat. 60°54′ N, Long. 45°14′ W. *Leg.* Bent Fredskild (C). Specimens up to 15 cm high. Sterile. Other species found in the lake are *Myriophyllum alterniflorum, Potamogeton filiformis* Pers. and *P. gramineus* L. Altitude c. 230 m above sea level. pH = 7.6 and specific conductivity 72 µS cm^{-1}.
9. South Greenland: Skyggesø, 8 August 1988. Lat. 60°51′ N, Long. 45°22′ W. *Leg.* Bent Fredskild (C) (Fredskild, 1992). Specimens 7-8 cm high. Sterile. Other species found are *Potamogeton gramineus* and *Hippuris vulgaris* L. Altitude c. 50 m above sea level. pH = 7.7 and specific conductivity 85 µS cm^{-1}.
10. South Greenland: Lake at Akugdlit (Loc. E 3 in Fredskild, 1992). We have not seen specimens from this collection.
Comments: *Chara globularis* is the most common charophyte in Greenland. It is only found on the south and westcoast north to Søndre Strømfjord (Fig. 9). The species is common in Europe and parts of North America (Corillion, 1957, 1973). It is also found on Iceland (Langangen, 1972) and on Newfoundland (Mann, 1989). *Chara globularis* is well known from oligotrophic lakes, normally with a low content of lime which also seems to be the case in Greenland. pH is measured in the range 6.4-7.7 and specific conductivity in the range 57-112 µS cm^{-1} (observations on the labels and Fredskild, 1973). The locations are situated from 50 to 230 m above sea level. In Greenland *Chara globularis* is found in waters with *Potamogeton gramineus, P. filiformis, Myriophyllum alterniflorum, Hippuris vulgaris* and *Chara delicatula*. This agrees well with observations

elsewhere (Olsen, 1944; Corillion, 1957). The specimens studied were generally well developed, up to 25 cm in height. The fructification was generally poor, and fertile specimens were only found in 4 localities. This can be due to low temperatures or too short growth periods. Karling (1924) has shown experimentally that *Chara globularis* can develop gametangia at low temperatures (2-7° C) under continuous illumination.

Chara delicatula C. Agardh
Only one locality in Greenland (Fig. 9).

Figure 9. Known distribution of *Chara delicatula* in Greenland.

1. South Greenland: Lake west of Qagssiarssuk. 5. July 1970. Lat. 61°09′ N, Long. 45°33′ W. *Leg.* Bent Fredskild (C). Coarse specimens, up to 20-25 cm long. Sterile. There are three collections from this locality. The determination has been done on the following terms: Specimens with slightly swollen but not elongated stipulodes in upper series and isostichous cortex have been named *Chara globularis*, and specimens with elongated stipulodes in upper series and tylacanthous cortex have been named *Chara delicatula*. At present this is the only locality known containing this species. Presumably it is much more common.

Comments: Many authors have treated *Chara globularis* and *Chara delicatula* as one species (Olsen, 1944; Langangen, 1972, 1974; Moore, 1986), while other have treated them as two species (Migula, 1897; Groves & Bullock-Webster, 1924; Corillion, 1957). Because of the confused taxonomy of this species, its distribution is only known in part. In insular Newfoundland it is the most common *Chara* (Mann, 1989). It is also common in the British Isles (Moore, 1979; Moore & Greene, 1983). In addition it is found in Iceland (Langangen, unpublished data). *Chara delicatula* is probably widely distributed throughout Europe (Corillion, 1957). Its ecology is similar to *Nitella flexilis* and *Chara globularis*.

Species only reported in literature

Chara baltica Bruz.
Only one known locality in Greenland (Fig. 10).

This species is reported from Greenland by Braun & Nordstedt (1882), who says: "Nord-Amerika. Grönland (*leg.* Raben, *in herb.* Sonder). *Forma internodiis valde elongatis, verticillis brachyphyllis clausis microcantha*". This means that this is a type with elongated internodes, short branchlets and with spine-cells shorter than the

Figure 10. Known distribution of *Chara baltica* in the northern Hemisphere. For localities out of Greenland, see Corillion (1957), Langangen (1974) and Moore & Greene (1983).

stem-diameter. Fredrik C. Raben who collected the plant, visited Greenland in 1823 (Anonymous 1824, 1826; C. Christensen, 1924; Porsild, 1935) where he stayed from June to August. He traveled from Godthåb to Fredrikshåb, and visited many areas around and between these two places (Anonymous, 1924, 1926). Without having seen any specimens, it is most reasonable to guess that the species was collected in late July or in August when he was in the area of Fredrikshåb.

Chara baltica is a brackish water species common in the Baltic Sea and found scattered along the European coasts to North-Africa (Corillion, 1957, 1973; Garcia, 1993). In the British Isles the species is found in southern England, in the Orkney Islands and in the Shetland Islands (Moore & Greene, 1983) (Fig. 10). The finds of *Chara baltica* in Greenland and Bolivia (the Titicaca Lake) (Braun & Nordstedt, 1882) and in Brazil (Hasslow, 1934) have not been accepted by several authors, as no specimens have been found (Wood, 1965; Bicudo, 1977 and Garcia, 1993). The species has recently been found and described from three new localities in Argentina (Garcia, 1993). If the find of *Chara baltica* in Greenland is correct, and we do believe this is so as the determination was made by Braun himself, it is most probably found in the area around Fredrikshåb and not on the east coast as proposed by Corillion (1957). If this is correct, the species has an amphi-atlantic distribution without reaching the North American continent. The finds in Argentina can therefore most reasonably be explained by long distance dispersal by birds. Some phanerogames are known to have a similar distribution, e.g. *Carex arctogena* H. Sm. (Nordal, 1985).

DISCUSSION

This paper gives a preliminary report on the charophytes of Greenland. According to ecological criteria the species can be grouped in three categories:
1. Oligotrophic species: *Nitella flexilis, N. opaca, Tolypella canadensis, Chara globularis* and *Chara delicatula*. All these species have wide ecological amplitudes for most physical and chemical parameters (Olsen, 1944; Langangen, 1972; Mann, 1989), and the Greenland finds correspond with these facts.
2. Species found in lime rich lakes: *Chara contraria*. The correlation between the lime content of the localities and the occurrence of this species is well documented (Langangen, 1972; Mann, 1989).
3. Brackish water species: *Chara canescens*, (*Chara aspera*, not found, but is probable), *C. baltica* (literature) and *Tolypella nidifica* f. *groenlandica*. The two *Chara* species have, as in the case of *Tolypella*, most probably been found in a salt lake or in a brackish water lagoon on the west coast (e.g. Godthåb) or in one of the many salt lakes in Søndre Strømfjord (Böcher, 1949, 1959; Røen, 1971).

The charophytes are generally found in the continental, low Arctic interior of Greenland (Fredskild, 1992) with only one exception: Holsteinsborg, where the climate is low-arctic, fairly oceanic. The general distribution of charophytes match the distribution of the low Arctic phanerogams, *Menyanthes trifoliata* L. and *Sparganium hyperboreum* L. (Fredskild, 1992). Of the 31 Greenland limnophytes mapped by Fredskild (1992), 25 are low Arctic, and of these, four grow in North America and Greenland and six are amphi-atlantic. These latter can be found on both sides of the Atlantic including Greenland. The amphi-atlantic distribution concerns all types of plants, including phanerogams. This kind of distribution has been much debated, especially in Europe (Dahl, 1958). The question is whether this distribution can be explained either by a land bridge (Dahl, 1958, 1991; Rognes, 1986) or by long-distance dispersal either by drifting ice and icebergs or by migrating birds (Nordal, 1985). For charophytes as for limnophytes in general both suggestions may be possible, although dispersal by means of birds is more probable. It has been demonstrated both by experiments and by observations that such long distance dispersal is possible (Vlaming & Proctor, 1968; Carlquist, 1974). Furthermore, it is well documented that different species of shore birds and waterfowls can ingest and disperse charophyte oospores over long distances (Imahori, 1954; Proctor 1962, 1967, 1968).

Both direct flights in both directions across the Atlantic and shorter steps via Iceland and Greenland can give vital clues to explain the charophyte-flora of Greenland. In this connection the charophyte-flora of insular Newfoundland (Mann, 1989) is of interest as it is similar to that of Greenland. Eleven species of charophytes are today known from insular Newfoundland (Mann, 1989, 1994). Most of these finds represent new northern and north easternmost finds in North America proved by data given by Wood (1967).

The Newfoundland charophyte flora may have an origin in southern parts of America as proposed by Khan & Sarma (1984), but it can also be explained by dispersal from Europe via Greenland. This has also been discussed by Mann (1994). The amphi-atlantic distribution of *Tolypella canadensis* Sawa is perhaps a circumstantial evidence for such a suggestion (Langangen, 1993a). It seems that bird migrations

occur mostly from the Old World, via Iceland to Greenland and North Canada rather than from North America (Alerstam *et al.*, 1986). This can be explained by the slower postglacial melting of the icesheet covering North America. Another factor is the distance to favourable wintering areas which is much shorter to the European countries than to similar American areas (Alerstam *et al.*, 1986). As Newfoundland is the the first/last landfall for birds moving either westward from Europe via Greenland/Iceland and for birds travelling along the North American migration routes (Alerstam, 1990), many vagrants from both continents are found here. Of all vagrant shorebirds and waterfowls, 38% are of European origin. In addition, many regular members of the avifauna are of European, Greenlandic or Icelandic origin. One of the vagrants is the White-fronted Goose, *Anser albifrons* Scopoli (Montevecchi & Tuck, 1987). Many species are possible vectors for dispersal of charophytes to Greenland, both shorebirds and geese (Salomonsen, 1971). The most common bird actually migrating from Europe is the White-fronted Goose which winters in Ireland and Scotland. In the spring migration, these birds use Iceland as a stopover site. Then they continue to the Denmark Strait and then cross the indland ice to western Greenland, where the many interesting finds of charophytes have been made in Greenland. Corresponding species can be found in Ireland and Scotland. Other species of birds using the same migration route breed in other parts of Greenland (Salomonsen, 1971).

The deglaciation of the coastal areas of Greenland began c. 11,000 years ago (Fredskild, 1973). Pollen analysis and microscopic algae have shown that the ecological conditions were much different up to c. 4,000 B.P., with higher water temperatures, more alkaline lakes and consequently a much higher production of the limnophytes (Fredskild, 1992). Fredskild (1977, 1983, 1992) has shown that the general frequency of charophytes was much higher in this period, and that charophytes arrived c. 9-9,500 B.P. These charophytes must have been of European origin. In all, fossil charophytes have been reported from 15 different waters. In 12 of these they are now extinct (Fredskild, 1992). Of 10 cored Godhåbsfjord lakes, as many as 8 had charophytes in the pioneer stage (Fredskild, 1992). Only one of these localities has charophytes today (lake at Itivnera). Recently Eisner *et al.* (1995) have found 5,000 years old oospores of *Tolypella* and *Chara* in sediments in a lake in Søndre Strømfjord where they disappeared at about 4,000 B.P. Oospores of *Nitella* cf. *flexilis* dominate the core from c. 2,000 B.P. What we see today of charophytes in Greenland are presumably remains of an earlier much richer charophyte-flora. Oospores of charophytes have also recently been found of Plio-Pleistocene age (2-2,5 million years ago) in Peary Land (82°30′ N) (Bennike, 1990).

Of the 9 species found in Greenland, 5 are common both in Europe and northern America. One (*C. canescens*) has its main distribution in Europe with a few finds in Northeast America; one (*Tolypella canadensis*) with a northern amphi-atlantic distribution; one (*C. baltica*) mainly found in Europe and with a few localities in S. America; and one species (*T. nidifica*) with a European distribution only. This in addition to the early immigration of charophytes to Greenland and the development of bird migration routes from Europe to Greenland support the hypothesis that the charophytes of Greenland originally are closer to the European flora than to the North American. As already emphasised the charophyte flora of Greenland is presumably only known in parts. Information on Greenland charophytes will be of principal interest, as the area is in the outmost limit of the distribution of these plants. It is therefore important to make new and additional collections. Areas of special interest are the borders between the high — and low-Arctic zones and especially the many salt

lakes e.g. in Søndre Strømfjord and Umanak Fjord (Røen, 1971; Böcher, 1949) or other places. The cambro-silurian areas in the north are presumed to be too cold for charophytes since very few limnophytes can survive here (Røen, 1968; Fredskild, 1992).

ACKNOWLEDGMENTS — We are indebted to Dr Werner Krause (Germany) for positive attitude in general, and for his help in determining *Tolypella canadensis*, to Dr Bent Fredskild (Denmark) for information around the finds of charophytes in Greenland, to late Professor Dr Oskar Garstein (Norway) for help with the manuscript and to Professor Dr Robert Corillion (France) for his translation of the French summary.

REFERENCES

ALERSTAM T., 1990 - *Bird Migration*. Cambridge University Press, Cambridge, 420 p.

ALERSTAM T., HJORT C., HÖGSTEDT G., JÖNSSON P.E., KARLSSON J. & LARSSON B., 1986 — Springmigration of birds across the Greenland Inlandice. *Meddelelser om Grønland, Bioscience* 21: 1-38.

ALLEN G.O., 1950 — *British Stoneworts (Charophyta)*. The Haslemere Natural History Society. Surrey. 52 p.

ANONYMOUS (= F.C. RABEN), 1824 and 1826 — Udtog af en Dagbog, holdet paa en Rejse i Grønland i Sommeren 1823. *Tidsskrift for Naturvidenskaberne* 3: 271-289 and 4: 1-35.

BENNIKE O., 1990 The Kap København Formation: stratigraphy and palaeobotany of a Plio-Pleistocene sequence in Peary Land, North Greenland. *Meddelelser om Grønland, Geoscience* 23: 1-85

BICUDO R.M.T., 1977 - O gênero Chara (Charophyceae) no Brasil, 2: Secção *Chara*. *Trabalhos Do XXVI Congresso Nacional de Botânica, Rio de Janeiro 1975* pp. 23-32.

BRAUN A. & NORDSTEDT O., 1882 — Fragmente einer Monographie der Characeen. Nach den hintenlassenen Manuscripten A. Braun's herausgegeben von Dr. O. Nordstedt. *Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin 1882* pp. 1-211.

BURROWS E.M., 1991 *Seaweeds of the British Isles. 2 Chlorophyta*. London, HMSO Books, The Natural History Museum. 238 p.

BÖCHER T.W., 1949 — Climate, soil, and lakes in continental West Greenland in relation to plant life. *Meddelelser om Grønland* 147: 1-63.

BÖCHER T.W., 1954 - Oceanic and continental vegetational complexes in Southwest Greenland. *Meddelelser om Grønland* 148: 1-336.

BÖCHER T.W., 1959 — Floristic and ecological studies in middle West Greenland. *Meddelelser om Grønland* 156: 1-68.

CARLQUIST S., 1974 *Island Biology*. Columbia University Press, New York, 660 p.

CHRISTENSEN C., 1924-1926 — *Den danske Botaniks Historie fra de ældste Tider til 1912*. København. I: 242-243.

CHRISTENSEN T., 1991 — On some Cladophoreae (Chlorophyta) with long unbranched filaments. *Archiv für Protistenkunde* 139: 9-19.

COMELLES M., 1986 *Tolypella salina* Corillion, caroficea nueva para España. *Anales Jardin Botánico de Madrid* 42: 293-298.

CORILLION R., 1957 — *Les charophycées de France et d'Europe Occidentale*. Travaux du Laboratoire de botanique de la Faculté des sciences d'Angers. Angers, 499 p. (Reprint, Otto Koeltz Verlag, Koenigstein-Taurus, 1972).

CORILLION R., 1960 - *Tolypella salina*, sp. nov., Charophycée nouvelle des marais de Croix-de-Vie (Vendée). *Revue Algologique, n.s.*, 3: 195-207.

CORILLION R., 1973 — Aspects généraux de la distribution géographique des Characées africano-malgaches. *Compte Rendu des Séances de la Société de Biogéographie, 49e année,* 431: 64-81.

CORILLION R., 1982 — Les Characées des iles Kerguelen. *Bulletin de la Société d'Etudes scientifiques de l'Anjou, n.s.*, 11: 47-64.

CORILLION R., & REVIERS, B. de., 1985 — Nouvelles observations sur *Tolypella antarctica*, Characée endémique Australe (Iles Kerguelen). *Cryptogamie, Algologie* 6: 25-34.

DAHL E., 1958 — Amfiatlantiske planter (Problems of amfiatlantic plant distribution). *Blyttia* 16: 93-121.

DAHL E., 1991 — Nunatakkteorien III-amfiatlanter og disjunkter (The nunatac theory III-amphiatlants and disjuncts). *Blyttia* 49: 17-33.

EISNER W.R., TÖRNQVIST T.E., KOSTER E.A., BENNIKE O. & LEEWEN J.F.N. van, 1995 — Paleo-ecological studies of a Holocene lacustrine record from the Kangerlussuaq (Søndre Strømfjord) region of West Greenland. *Quaternary Research* 43: 55-66.

FREDSKILD B., 1973 — Studies in the vegetational history of Greenland. *Meddelelser om Grønland* 198: 1-247.

FREDSKILD B., 1977 — The development of the Greenland lakes since the last glaciation. *Folia Limnologica Scandinavica* 17: 101-106.

FREDSKILD B., 1983 — The Holocene development of some low and high arctic Greenland lakes. *Hydrobiologia* 103: 217-223.

FREDSKILD B., 1992 — The Greenland limnophytes-their present distribution and Holocene history. *Acta Botanica Fennica* 144: 93-113.

GARCIA A., 1993 — *Chara baltica* Bruzelius (Charophyta) en Argentina. *Candollea* 48: 297-303.

GROVES J. & BULLOCK-WEBSTER G.R., 1920 — *The British Charophyta. Vol. I. Nitelleae.* London, The Ray Society, 141 p.

GROVES J. & BULLOCK-WEBSTER G.R., 1924 — *The British Charophyta. Vol. II. Chareae.* London, The Ray Society, 129 p.

HALLIDAY G. L., KLIM-NIELSEN L. & SMART I.H.M., 1974 — Studies on the flora of the north Blosseville kyst and the hot springs of Greenland. *Meddelelser om Grønland* 199: 1-47.

HANSEN J.B. 1985 - *An Outline of Phycology in Denmark*. The second International Phycological Congress. Copenhagen, 24 p.

HARTZ N., 1898 — Botanisk Rejseberetning fra Vest-Grønland 1889-1890. *Meddelelser om Grønland* 15: 1-60.

HASSLOW O., 1934 — Några characeer från Amerika. *Botaniska Notiser* 1934: 346-347.

HASSLOW O., 1939 — Einige Characeenbestimmungen. *Botaniska Notiser* 1939: 295-301.

HORNEMAN J.W., 1816 — *Flora Danica* 9: 26. Copenhagen.

IMAHORI K., 1954 — *Ecology, Phytogeography and Taxonomy of the Japanese Charophyta.* Kanazawa University, 234 p.

JESSEN P., 1987 — *Morten Wormskjold-den glemte opdagelsesrejsende*. København, Forlaget Agitryk. 60 p.

KARLING J.S., 1924 — A preliminary account of the influence of light and temperature on growth and reproduction in *Chara fragilis*. *Bulletin of the Torrey Botanical Club* 51: 469-488.

KASHIMURA T., 1960 — The influence of some ecological factors on the growth of *Nitella flexilis*. *The Scientific Reports of the Tôhoku University, 4the Ser. (Biol.)* 26: 111-123.

KHAN M. & SARMA Y.S.R.K., 1984 — Cytogeography and Cytosystematics of Charophyta. *In*: IRVINE D.E.G. & JOHN M. (eds.), *Systematics of the Green Algae*. Systematics Assoc. 27: 301-330. Academic Press. London.

KRUUSE C., 1912 — Rejser og botaniske Undersøgelser i st-Grønland mellem 65°30' og 67°20' i aarene 1898-1902 samt Angmagsalik-egnens Vegetation. *Meddelelser om Grønland* 49: 1-307.

LANGANGEN A., 1972 — The Charophytes of Iceland. *Astarte* 5: 27-31.

LANGANGEN A., 1974 — Ecology and distribution of Norwegian charophytes. *Norwegian Journal of Botany* 21: 31-52.

LANGANGEN A., 1979 — *Chara canescens* reported from Spitsbergen. *Phycologia* 18: 436-437.

LANGANGEN A., 1993a — *Tolypella canadensis*, a charophyte new to the European flora. *Cryptogamie, Algologie* 4: 221-231.

LANGANGEN A., 1993b — Kransalgene i Nordland (The charophytes of Nordland). *Polarflokken* 17: 491-518.

LANGANGEN A., 1994 — *Tolypella normaniana* Nordstedt, a little known charophyte from Northern Norway. *Cryptogamie, Algologie* 15: 221-236.

LANGANGEN A. & BLINDOW I., 1995 — The charophyte *Tolypella canadensis* in Scandinavia. *Polarflokken* 19 (2): 131-137.

LÆGAARD S., 1960 — Two species of *Potamogeton* new to Greenland. *Botanisk Tidsskrift* 56 (København): 247-250.

MANN H., 1989 - Charophytes of Insular Newfoundland. *Canadian Field-Naturalist* 103: 34-42.

MANN H., 1994 — The Genus *Tolypella* (Characeae) in Insular Newfoundland. *Canadian Field-Naturalist* 108: 297-304.

MIGULA, W., 1897 — Die Characeen. *In*: RABENHORST L., *Kryptogamen-flora von Deutschland, Oesterreich und der Schweiz, Vol. V.* Leipzig, 765 p. (Johnson Reprint, New York, 1971).

MONTEVECCHI W.A. & TUCK L.M., 1987 — *Newfoundlands birds: Exploitation, study, conservation.* Nuttal Ornithological Club. Publication No. 21. Cambridge, Massachusetts, 273 p.

MOORE J.A., 1979 — The current status of the Characeae (Stoneworts) in the British Isles. *Watsonia* 12: 297-309.

MOORE J.A., 1986 — *Charophytes of Great Britain and Ireland.* BSBI Handbook No. 5. London, 140 p.

MOORE J.A., & GREENE D.M., 1983 - *Provisional atlas and catalogue of British Museum (Natural History) specimens of the Characeae.* Biological Records Centre. Huntington, 121 p.

NORDAL I., 1985 — Overvintringsteori og det vestarktiske element i skandinavisk flora (The theory of ice-free refugia and the West Arctic element in the Scandinavian flora). *Blyttia* 43: 185-193.

OLSEN S., 1944 — Danish Charophyta. Chorological, ecological and biological investigations. *Det Kongelige Danske Videnskabernes Selskab, Biologiske Skrifter* 3: 1-240.

PORSILD M.P., 1935 — Stray contributions to the flora of Greenland VI-XII. *Meddelelser om Grønland*, 93: 1-94.

PROCTOR V.W., 1962 — Viability of *Chara* oospores taken from migratory waterbirds. *Ecology* 43: 528-529.

PROCTOR V.W., 1967 — Storage and germination of *Chara* oospores. *Journal of Phycology* 3: 90-92.

PROCTOR V.W., 1968 - Long-distance dispersal of seeds by retention in digestive tract of birds. *Science* 160: 321-322.

ROBINSON C.B., 1906 — The Chareae of North America. *Bulletin of the New York Botanical Garden* 4: 244-308.

ROGNES K., 1986 — Problemet vest-arktisk utbredelse (The West-Arctic distribution pattern). *Blyttia* 44: 76-81.

RØEN U.I., 1962 — Studies on Freshwater *Entomostraca* in Greenland. II. Localities, ecology, and geographical distribution of the species. *Meddelelser om Grønland* 170: 1-249.

RØEN U.I., 1968 - Studies on Freshwater *Entomostraca* in Greenland. III. *Entomostraca* from Peary Land with notes on their biology. *Meddelelser om Grønland* 184: 1-59.

RØEN U.I., 1971 — Grønlands ferskvande (Lakes of Greenland). *In*: BÖCHER T.W., OVERGAARD NIELSEN C. & SCHOU A. (eds), *Danmarks Natur* 10: 383-398. København.

SALOMONSEN F., 1971 - Grønlands landfugle (Birds of Greenland). *In*: BÖCHER T.W., OVERGAARD NIELSEN C. & SCHOU A. (eds.), *Danmarks Natur* 10: 420-444. København.

SAWA T., 1973 — Two new species of *Tolypella* (Characeae) from North America. *Journal of Phycology* 9: 472-482.

STROEDE W., 1933 — Über die Beziehungen der Characeen zu den chemischen Faktoren der Wohngewässer und des Schlammes. *Archiv für Hydrobiologie* 25: 192-229.

VLAMING V.L. de & PROCTOR V.W., 1968 — Dispersal of aquatic organisms: Viability of seeds recovered from the droppings of captive killdeer and mallard ducks. *American Journal of Botany 55*: 20-26.

WARMING E., 1890 — Morten Wormskiold. En biografisk Skizze med Portræt. *Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjøbenhavn* 51: 253-281.

WOOD R.D., 1965 — Monograph of the Characeae. *In*: WOOD R.D. & IMAHORI K. (eds.), *A revision of the Characeae*, Vol. I. Weinheim, Cramer, pp. 1-904.

WOOD R.D., 1967 — *Charophytes of North America*. Stella's Printing. West Kingston, Rode Island, 72 p.

WOOD R.D. & IMAHORI K., 1959 — Geographical distribution of Characeae. *Bulletin of the Torrey Botanical Club* 86: 172-183